Using Artificial Team Members for Military Team Training in Virtual Environments

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ABSTRACT

Developing good team skills usually involves exercises with all team members playing their role. This approach is costly and has organizational and educational drawbacks. For the Netherlands army, we developed a more efficient and flexible approach by setting training in virtual environments, and using intelligent software agents to play the role of team members. We developed a general framework for developing agents that, in a controlled fashion, execute the behavior that enables the human player (i.e., trainee) to effectively learn team skills. The framework is tested by developing and implementing various types of team agents in Virtual Battle Space 2 (VBS2).

1.0 INTRODUCTION

Usually, team skills are trained by exercises with a (potentially large) number of participants, each playing a dedicated role in a given scenario. This type of team training requires ample resources (both human and financial) and is difficult to organize. The Netherlands Army is in need of new forms of team training that require less organizational and logistic efforts. A solution would be to use virtual humans (agents) to play the roles of team members autonomously. If we can develop agents that in training scenarios produce intelligent and realistic behavior of the individual that they represent, team training can become more traceable, more systematic, and more cost-efficient.

In collaboration with subject matter experts of the Netherlands Army, we approach this challenge by developing a game-based platform for team training in which some team members are played by humans, and some are played by software agents. In this way, costs of team training can be reduced, as not all roles have to be fulfilled by humans anymore. Furthermore, training can be better tailored to the specific learning objectives of a specific individual, as we can control more precisely the team behavior of artificial team members than that of human team members (which may be trainees themselves).

We tested our approach of agent-based training for hierarchical teams and peer-to-peer teams. For the training of an hierarchical team, we used a house search scenario. The commander is played by a human trainee. It is his task to lead a house search operation performed in cooperation with three virtual soldiers. The soldiers deviate from the original plans laid out by the commander. They do so because the proposed hard approach does not seem appropriate to the friendly situation encountered in the house (e.g. innocent women and children are present). This requires the trainee commander to realize that his original plans seem no longer appropriate, and to take a more comprehensive approach.

For the training of peer-to-peer teams we developed a task in which a group of humans and a virtual team member collaboratively explore a village to search for weapons hidden by terrorists. The team behavior of the virtual team member can be controlled on different dimensions. Consequently, the difficulty of cooperating with the virtual team member can be adapted to the skill-level of the human trainee.

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The remainder of this paper is organized as follows. In Section 2, we describe training in hierarchical teams. In Section 3, we describe team training in peer to peer teams. The computational cognitive models used in these applications are described in Section 4. We report our conclusions in Section 5.

2.0 PROVIDING TRAINING FOR HIERARCHICAL TEAMS

Hierarchical teams are characterized by a strong leader who is responsible for achieving the goals of the mission. The task of the leader is to ensure that he and his subordinates do the right things, at the right moments, in the right way. Being a good leader requires specific skills, involving behaviors like:

- Instructing subordinates in a clear and motivating way, taking into account their different personalities and attitudes
- Planning and replanning in an uncertain and highly dynamic environment
- Collecting the right information from subordinates to make well-informed decisions

To train the capabilities described above, we used a house search case. In this case the trainee experiences difficult situations, and learns how to solve problems under time pressure.

2.1 House Search Case

In the house search case, the commander (the trainee) is given orders by the peloton commander to pick up three potentially armed locals from their hiding place. The commander is given intelligence about the structure of the building, and about potential risks that may be encountered. The orders emphasize to refrain form actions that may cause further damage to winning *the hearts and minds* of the people, as in several recent incidents harm was inflicted upon innocent civilians. After the briefing by the peloton commander, the commander must instruct his men how to perform the house search, e.g. following a soft-knock or a hard-knock approach. When the commander enters the house with his men, they encounter a medium-sized room with three men drinking tea, and rifles lying on the ground. The challenge of the commander is to correctly assess the situation as a friendly situation (the presence of rifles is not necessarily a sign of hostility in that region), and to ensure that his men act accordingly.

Figure 1: A screenshot of the House Search Case scenario developed in VBS2.

3.0 PROVIDING TRAINING FOR PEER TO PEER TEAMS

A Peer-to-peer team can be described as a group of people working together on equal level to achieve a common goal. A good team member maintains *common ground*, is *mutually predictable*, and is *mutually directable* [3]. *Common ground* refers to knowledge, beliefs, and assumptions that enable the involved parties to comprehend the messages and signals that help coordinate joint actions. *Mutual predictability* enables team members to predict what the others will do. This helps them in planning and coordinating their own actions. *Mutual directability* refers to the capacity for deliberately modifying other parties' actions in a joint activity.

Whereas we believe these properties to be essential for team membership, *how* these properties reveal themselves in behavior may vary. By explicitly modeling such differences in artificial team members we can expose trainees to different types of team behavior. For all three aspects discussed above, we can configure our agent in either *provocative* mode or *unprovocative* mode. When the agent maintains common ground in an unprovocative way, it always shares relevant information. When it maintains common ground in a provocative way, it sometimes refrains from sharing relevant information. This obliges the trainee to actively collect relevant information. When mutual predictability is implemented in a unprovocative way, the agent is fully organization aware; when it is implemented in a provocative way, the agent is not (fully) organization aware. This obliges the trainee to improve the collaboration with the virtual team member by communicating his or her own roles. Provocative mutual directability means that the agent will not unconditionally obey a request from the trainee. The trainee should then convince the agent that the requested action is in the best interest for the team as a whole. In contrast, when the agent is in unprovocative mutual directable mode, it will act upon any request issued by the trainee.

3.1 Village Search Case

The scenario chosen is the standard NATO SABRE experimental environment [3]. It is a small fantasy city with residential and commercial areas. This scenario was created to investigate the differences in task-approach, execution and performance in different cultures within NATO countries. In the SABRE environment a team of four members has to find, identify, and neutralize weapon crates hidden in (buildings of) the city. The team has several resources like scanners, lock-picking sets and bomb diffusers at their disposal to accomplish this task. The number of tools and the number of times they can be used are limited. Team cooperation and coordination is imperative to accomplish the mission while disturbing the local population as little as possible. Overall performance involve the number of nuetralied weapon crates, but also the 'goodwill' of the population. An in-game measure of performance is the team members' level of Situational Awareness (SA) at two predefined moments.

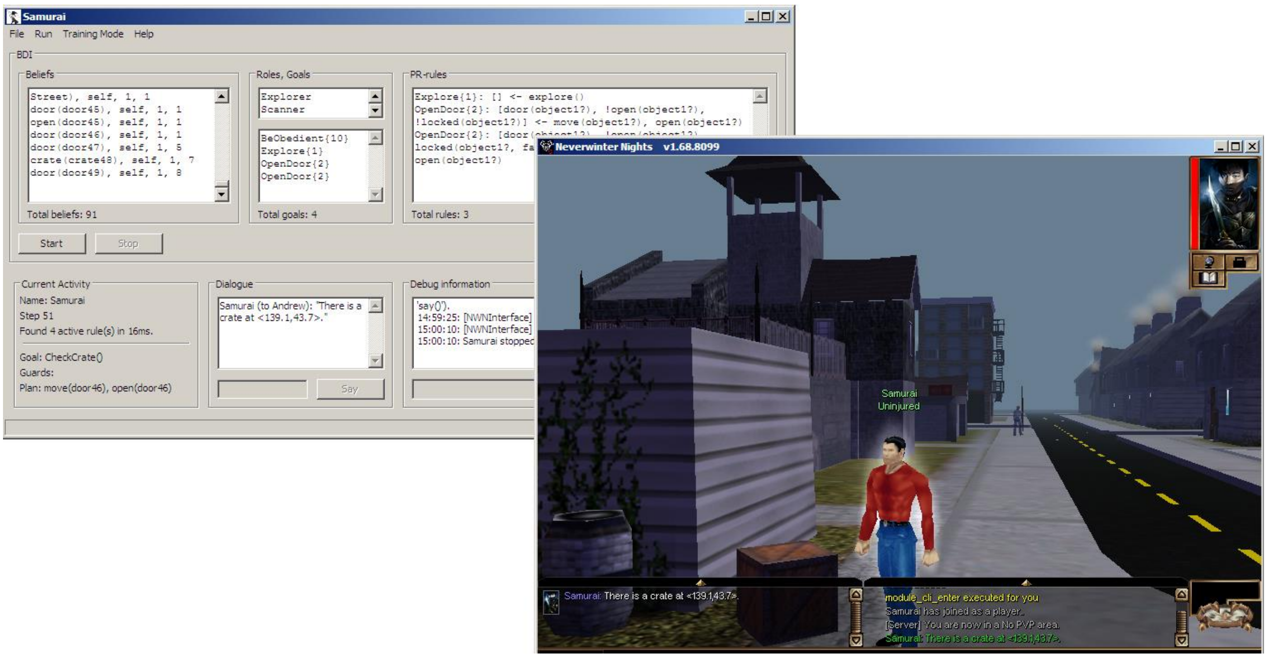

Figure 2: The agent's internal workings (left); the agent in the Sabre environment (Right).

4.0 COMPUTATIONAL COGNITIVE MODELS

This section briefly describes the use of cognitive models for generating behavior of virtual characters. For a more in-depth discussion, the reader is referred to [2]. To specify the behavior needed for the house - and village search scenarios, we build on Bratman's well known theory of practical reasoning [1] (aka BDI-theory). At the core of our model, an agent's behavior is modeled by specifying beliefs, goals and plans, and by writing formal rules which specify how beliefs and goals lead to action. To fine-tune the agent to meet the demands of the different scenarios, we add additional notions to our models. For the house search and the village search case, these are briefly described below.

In the house search case, the challenge was to program the team members in such a way that they could exhibit behavior matching different personal characteristics. We have done this by implementing goal conflicts, and different ways of dealing with these conflicts, depending on the characteristic. First, we distinguish the personal characteristic *newbie* vs. *leader*. If a newbie-agent encounters a goal conflict, it executes the action (or goal) which it was given by order (by the commander). The leader-agent on the other hand, gives priority to the goal it was given by internal motivation (e.g. stemming from prior experiences), and therefore sometimes ignores orders of the commander. Second, we distinguish the personal characteristic *peaceful* vs. *trigger happy* The peaceful -agent prefers goals (or actions) that do not lead to harming innocents, while the trigger happy -agenthas the tendency to prioritize goals that involve shooting.

To implement the agents needed for the village search case, we focused on maintaining common ground, mutual predictability, and mutual directablility (see Section 3). In an elementary way, we have implemented them as follows. An agent maintains common ground with his team members by actively sharing relevant pieces of information. Mutual predictability is achieved by applying an organizational structure to the team. All team members are familiar with this structure and it thus provides a shared understanding of how the different team members are performing their share of teamwork. Mutual directability is implemented by a *request* protocol, which allows one agent to ask another agent to perform an action. In provocative mode, the agent acts as an "imperfect" team member. Provocative mutual

predictability is implemented by restricting an agent's access to the organization model. The agent then initially has no knowledge of the roles of the other team members and therefore cannot decide what qualifies as relevant information. Provocative common ground is achieved by applying a random 'forget' function to the sharing of relevant information. As a result, the team agent will sometimes fail to communicate relevant information. Provocative mutual directability is implemented by making the agent attribute low priority to incoming requests, unless the request is motivated by specifying how the request can lead to a fulfillment of the team goal.

5.0 CONCLUSION

In this paper, we have described our approach for developing virtual team members for team training. We have distinguished between agents designed in such a fashion that they support a trainee in learning how to behave as a leader, and agents designed to support a trainee in learning to operate in peer-to-peer teams. For both applications, we believe that the learning experience can be optimized by developing agents that show natural and realistic behavior, and thus sometimes act imperfectly or even wrongly. The Netherlands Army is in the opinion that our approach to agent-based team training is promising, as our models yield behavior that is recognized as realistic for current military operations.

Our plans for the immediate future involve using the results and experiences reported in the present paper to develop effective and efficient team training programs. The training value of these programs will subsequently be investigated under experimentally controlled conditions.

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